NASA-CR-202170

FINAL REPORT

NASA Project Nag 3-1402

ABSOLUTE AND CONVECTIVE INSTABILITY OF A LIQUID JET AT MICROGRAVITY

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1. Objective

The objective of the project is to unveil the physical mechanism of a liquid jet breakup. The existing rigorous theories on the subject are based on the assumption that gravity is absent. The experiments performed in the microgravity facility at the NASA Lewis Research Center enable one to check the existing theories for the first time and reach the objective.

2. Significance

The processes of breaking up a liquid jet are applied in various industrial processes including fire suppression, fuel spray formation, toxin material removal, powder metalogy etc. Understanding of the fundamental mechanism of jet breakup will enable one to control the process to benefit human activities on earth as well as in a reduced gravity environment.

3. Description

The general layout of the components of the experimental apparatus is given in Fig. 1. A test liquid stored in the compressed liquid cylinder is driven by the pressurized Helium in the compressed gas cylinder through a pressure regulator. The test fluid passes through a series of sensors which measures the temperature, pressure and flow rate before reaching the nozzle from which the liquid jet emanates. The time evolution of the liquid jet is photographed with a high speed motion picture camera before the jet liquid is collected with a catch pan. The electrical power source required for the control of the hydraulic system, sensors and optical system is supplied by three battery packs which are not shown.

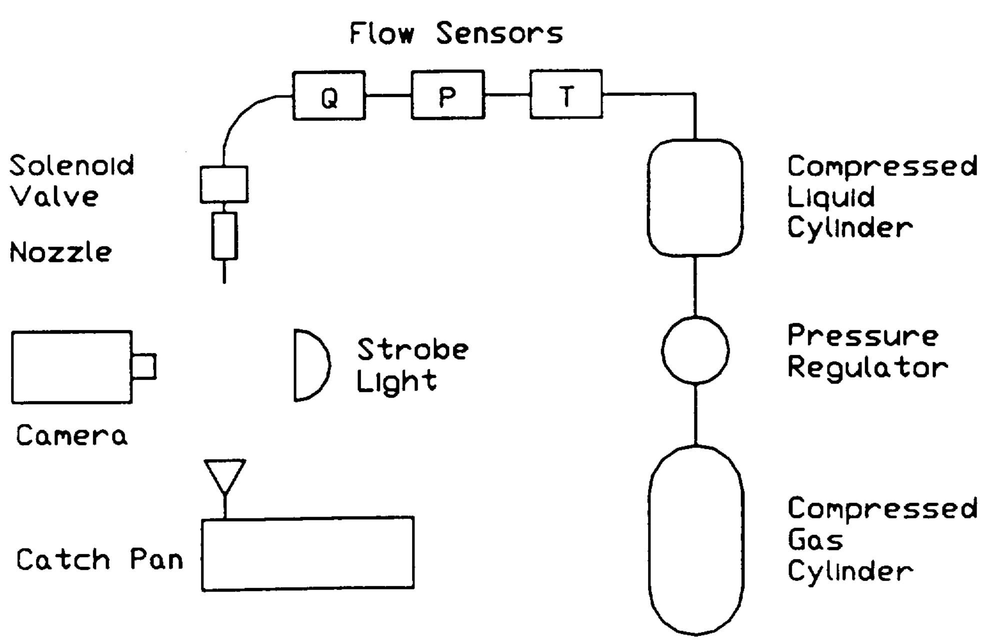

Figure 1: Experimental Layout

Figures 2 and 3 are photographs taken in the 2.2s drop tower. The former is the manifestation of convective instability, and the latter is the manifestation of absolute instability. Note the qualitative difference in the morphology of the two types of instabilities. While the disturbance energy propagates down stream in a convectively unstable jet, it propagates upstream in an absolutely unstable jet (see published works lists in section 4).

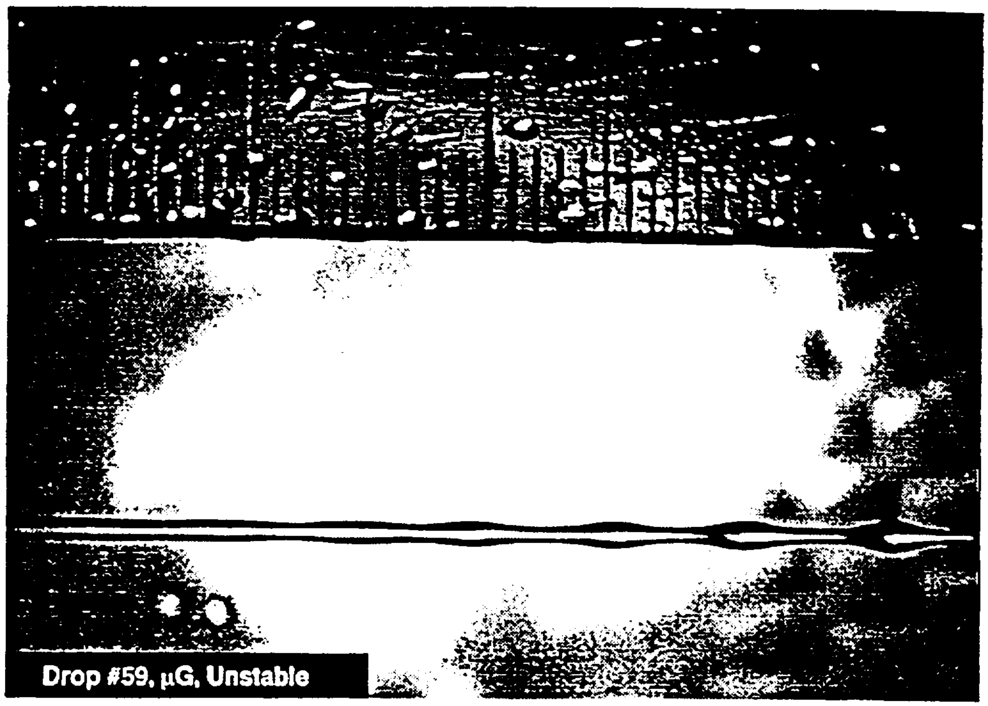

Figure 2: Manifestation of Convective Instability

Drop 59 (Re=160, We=0.01, k=1.7)

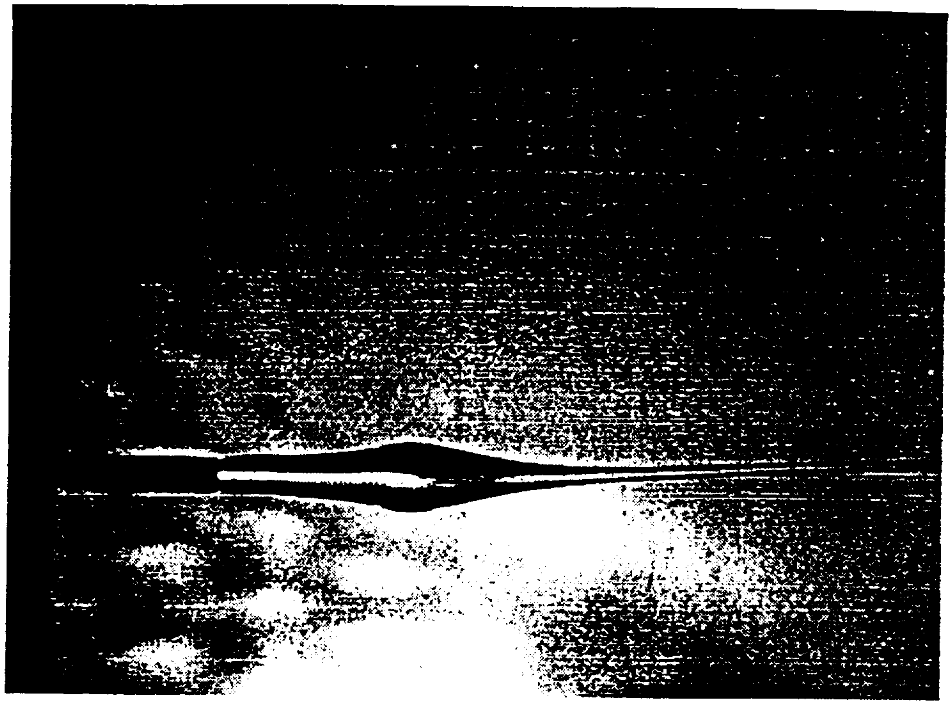

Figure 3: Manifestation of Absolute Instability

Drop 66 (Re=0.082, We=0.349, t=0.2s)

4. Progress

The most significant progress made to date is probably the evidence of the existence of absolute instability of a liquid jet which is demonstrated in the NASA Lewis Research Center 2.2 second-drop tower. This demonstration is the first in the world, and is documented in two MS thesis:

(1) Andrew M. Honohan, "Experimental Measurement of the Spatial Instability of a Viscous Liquid Jet at Microgravity", Clarkson University, 1995.

(2) Illari Vihinen, "Absolute and Convective Instability of a Liquid Jet in Microgravity", Clarkson University, MS Thesis, 1996.

(3) C.H Teng, "Absolute and Convective Instability of a Viscous Liquid Curtain in a Viscous Gas", Clarkson University, MS Thesis, 1996.

The published papers resulting from this project are:

1. "Absolute and Convective Instability of a Viscous Liquid jet Surrounded by a Viscous Gas in a Vertical Pipe", S.P. Lin and Z.W. Lian, Physics of Fluids A, 5, 771-773, 1993.

2. "Nonaxisymmetric Disturbances in a Liquid Jet", S.P. Lin and R.D. Webb, Proceedings, 2nd International Conference of Fluid Mechanics, Beijing, 121-124, 1993.

3. "Forced Atomization of a Liquid Jet", S.P. Lin and D.R. Woods, Proceedings of 2nd International Conference on Fluid Mechanics, Beijing, 1026-1031, 1993.

4. "Nonaxisymmetric Evanescent Waves in a Viscous Liquid Jet", S.P. Lin and R.D. Webb, Physics of Fluids 6, 2545-2547, 1994.
5. "A Branching Liquid Jet", S.P. Lin and R.D. Webb, Physics of Fluids, 6, 2671-2674, 1994.

6. "Regimes of Jet Breakup", S.P. Lin and M. Hudman, Proceedings of ICLASS ' 94, 1-7, 1994.